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Canada. Forest Products Laboratories

DEPARTMENT OF THE INTERIOR, CANADA

HON. THOMAS G. MURPHY,

*Minister*

W. W. CORY, C.M.G.,

*Deputy Minister*

E. H. FINLAYSON, B.Sc.F., *Director of Forestry*

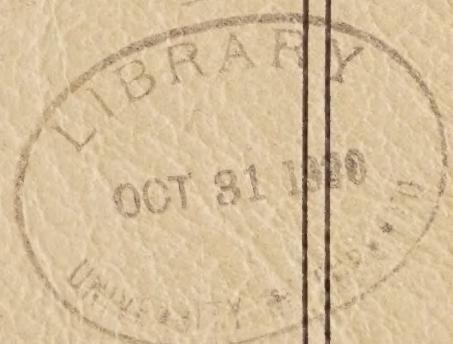
The Forest Products Laboratories  
of Canada

OTTAWA - MONTREAL  
VANCOUVER

BY

*Frank McElhanney*  
T. A. McELHANNEY, B.A.Sc.  
*Superintendent*

1886 -



F. A. ACLAND

PRINTER TO THE KING'S MOST EXCELLENT MAJESTY  
OTTAWA - 1930

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## THE FOREST PRODUCTS LABORATORIES OF CANADA

In all branches of industry there is a growing appreciation of the benefits which may be derived from scientific research. The Dominion Government has been alive to the development of this viewpoint and, in a great many cases, has led the way in providing facilities for investigating scientific problems of the primary industries concerned with the development of the country's natural resources.

In probably no industry has research been applied to greater advantage than in the timber-using industries. The pulp and paper industry has grown to be Canada's largest industry. The scientific problems which have been confronted in its development have been many and difficult, and there are still many unsolved. The same may be said with respect to equipment and methods of operation in the sawmilling and wood-working industries.

Forestry in Canada is concerned with two broad and general lines of activity: (1) the growing of the forest crop and (2) the conversion of this crop into commercial products. It is of the utmost importance that both these activities be conducted with the greatest efficiency and with a full realization of the value of continuous and permanent organization in carrying them out. In an industry, such as the timber industry, whose ramifications are so wide, and in a country such as Canada where there has been, so far, in general, an abundance of raw material, it is easy to understand why there has been, and in some cases still is, a high percentage of waste of raw material. Changing economic conditions are each year enhancing the value of wood, and this, together with the general development of public sentiment towards scientific research, is no doubt responsible for the greater interest which is being taken in the curtailment of waste by wood-using industries.

## ESTABLISHMENT OF FOREST PRODUCTS LABORATORIES

Representations from the lumbering and the pulp and paper industries to the Dominion Government, regarding the necessity of a forest products research organization under federal direction, took practical form in 1913, when the Forest Service of the Department of the Interior established the Forest Products Laboratories in Montreal on a site provided by McGill University. Starting as one comparatively small organization, the Laboratories have since outgrown their first inadequate quarters. Their investigations are now conducted in three well-equipped groups of laboratories: the main Laboratories located in Ottawa, Ont.; the Pulp and Paper division in Montreal, P.Q., and the Vancouver Laboratory in Vancouver, British Columbia.

### *The Vancouver Laboratory*

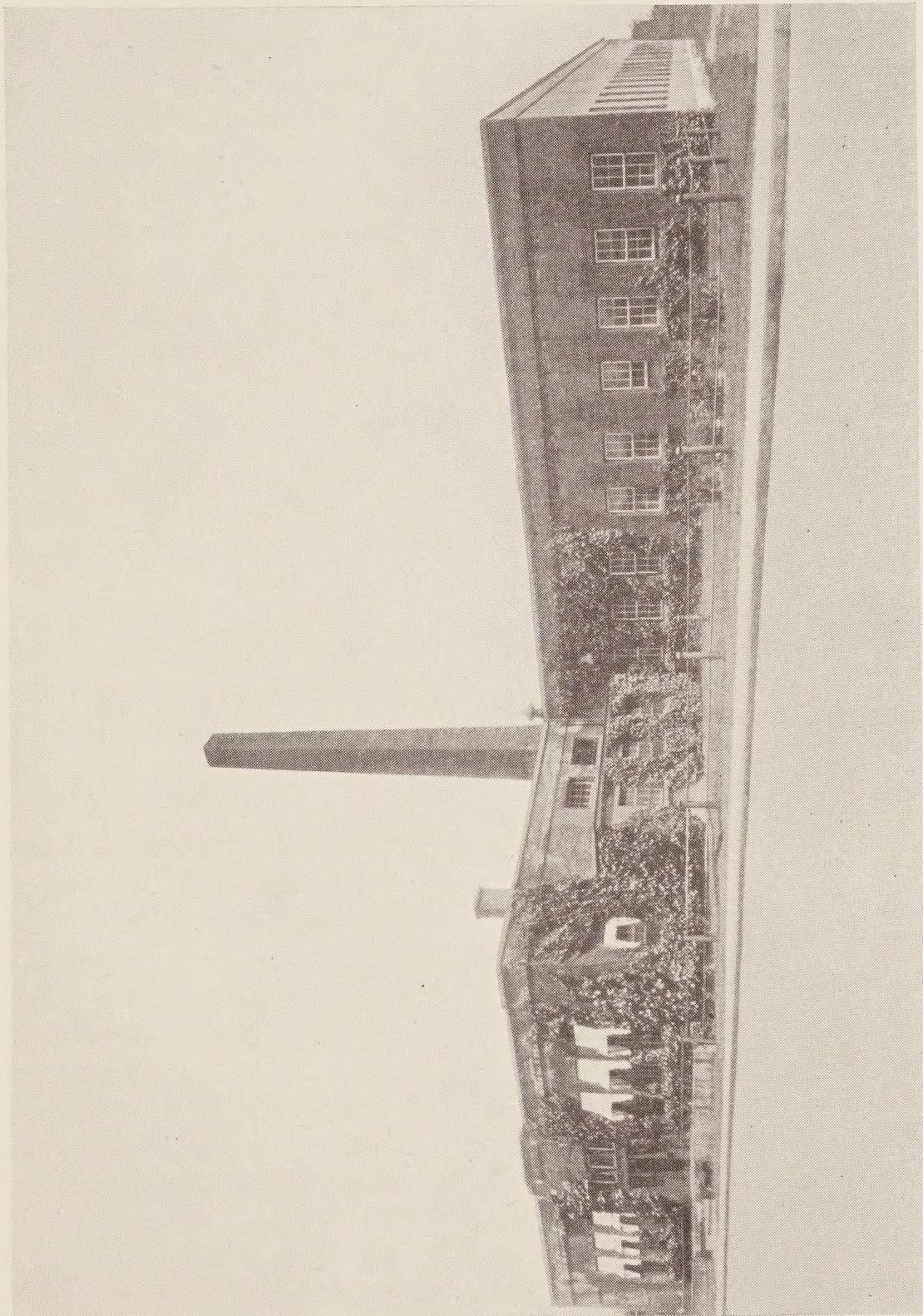
In 1918 there was an urgent demand for information regarding the mechanical and physical properties of some of the British Columbia woods which were available in large quantities and in timber of great size, for war purposes, particularly for aeroplane construction. A timber-testing laboratory was therefore established in Vancouver to meet this demand. So valuable did this branch laboratory prove, not only for determining the mechanical and physical properties of western species but for carrying out a wide range of investigations in problems pertaining to the use of the woods of British Columbia, that it was later found advisable to establish it in permanent quarters on the site of the University of British Columbia, to look after those special problems which could be dealt with to greater advantage locally than they could be in the Montreal Laboratories.

### *The Pulp and Paper Laboratory (Montreal)*

The work in the Pulp and Paper division of the Laboratories, especially after the war, developed so rapidly that the question of accommodation soon became acute. Besides,

# *The Forest Products Laboratories of Canada*

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THE FOREST PRODUCTS LABORATORIES OF CANADA, OTTAWA.

the rapid expansion of the pulp and paper industry during that period gave rise to a multitude of new problems and brought strong requests from this industry for more adequate facilities for pulp and paper research than were possible with the accommodation then available. The Pulp and Paper Association manifested its interest, in a very practical form, in 1925 when it offered to erect in Montreal a new building on the site of the old Forest Products Laboratories and to provide accommodation in this new building for the pulp and paper division of the Laboratories. Besides, this association offered to contribute for a period of five years an appreciable amount towards the maintenance of the pulp and paper division's research activities. An agreement was therefore entered into with the Pulp and Paper Association along these lines, and a building was erected by the Association in 1927.

#### *Removal of Main Laboratories to Ottawa*

The erection of the Pulp and Paper Research building necessitated the demolition of the old Laboratory buildings. The main Laboratories were, therefore, moved to Ottawa, where excellent accommodation was available.

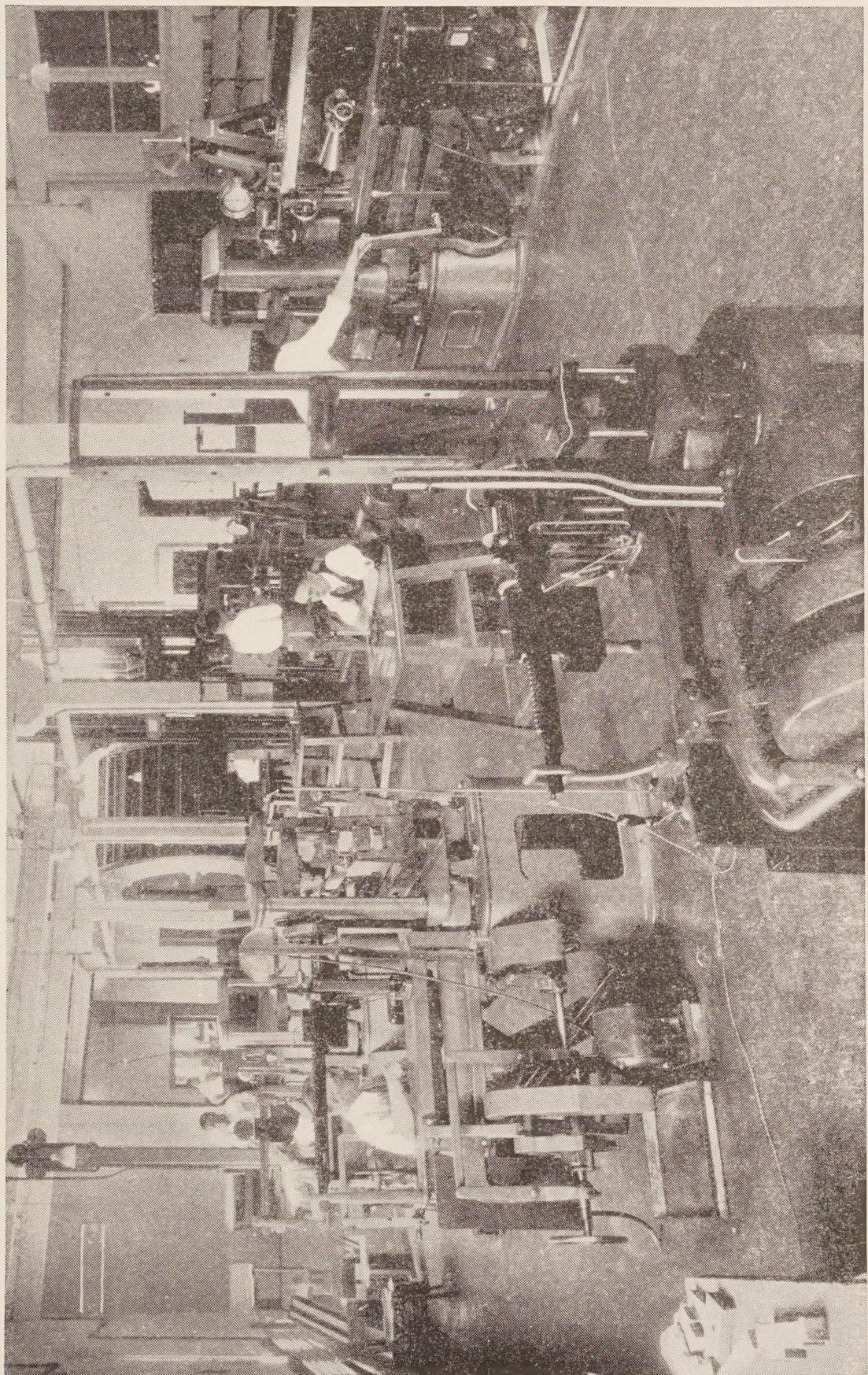
In order to understand fully the significance of forest products research to the wood-working industries of Canada, it is well to keep in mind a few facts with regard to these industries. It should not be forgotten that the lumber industry of Canada is second only to agriculture in the value of its products. Over \$600,000,000 is invested in the pulp and paper industry in Canada; the value of its gross annual production in Canadian mills is almost a quarter of a billion dollars. The value of the annual production of primary products such as lumber, lath, shingles, etc., in Canadian mills is about \$140,000,000.

### **SIGNIFICANCE OF RESEARCH IN THE WOOD-USING INDUSTRIES**

Reference has already been made to waste in the use of wood. In some logging operations, frequently over 25 per cent of the forest stand is left after logging operations,

# *The Forest Products Laboratories of Canada*

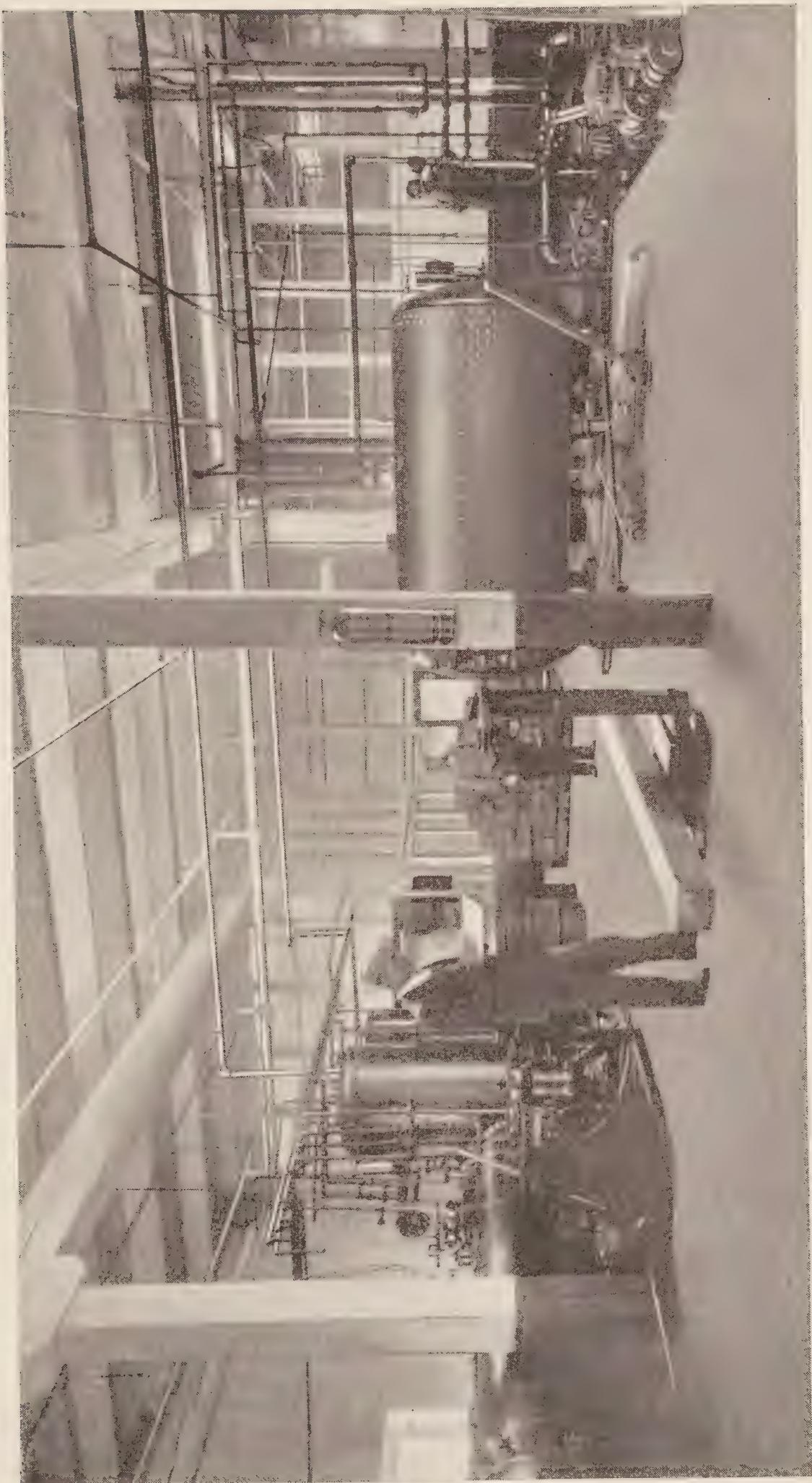
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THE TIMBER MECHANICS LABORATORY, OTTAWA.

as it cannot be used profitably under present conditions with respect to markets and methods of logging. Losses frequently as high as 20 per cent of the value of the green lumber are encountered in seasoning lumber. About 50 per cent of the wood which enters a chemical pulp digester is lost in the mill effluent. Large amounts of wood are still being consumed in wood-waste burners. Untreated timber is still being used to a very considerable extent for railway ties, poles, piling, bridge timbers and other exposed uses, even though it is known that its period of service can be greatly prolonged by the application of suitable preservatives. Stain and decay in the forests, in lumber-seasoning yards and in timber in use, each year, result in heavy losses; blue stain, alone, in white pine seasoning yards frequently accounts for an annual loss exceeding one million dollars. Curtailment of waste is not simply one of technique of process or use, nor is it one entirely of economics. It involves essentially a combination of the two.

There is a growing appreciation, on the part of users of wood, of the importance, from a national standpoint, of avoiding waste wherever economically possible. Pine shavings are being used in the manufacture of wood flour for use in the linoleum and explosives industries. Sawmill waste, of pulpwood species, is being chipped and sent to pulp-mills. On the Pacific Coast, particularly, material which a few years ago was being sent to the burners is being hogged and used for domestic and industrial heating. Pulp companies in Eastern Canada are devoting considerable attention to river transportation of logs, and seeking methods for reducing present sinkage losses in softwood and for bringing out hardwoods now left in the woods and largely wasted. Pulp and paper companies are seeking improvements in chemical pulping processes, having in view the increase of their percentage of recovery from raw wood. Railways and other large users of structural timber are resorting, to an increasing degree, to the use of treated timber. These are only a few of many instances where closer utilization of material is being sought. Such problems have, however, introduced a wide variety of technical



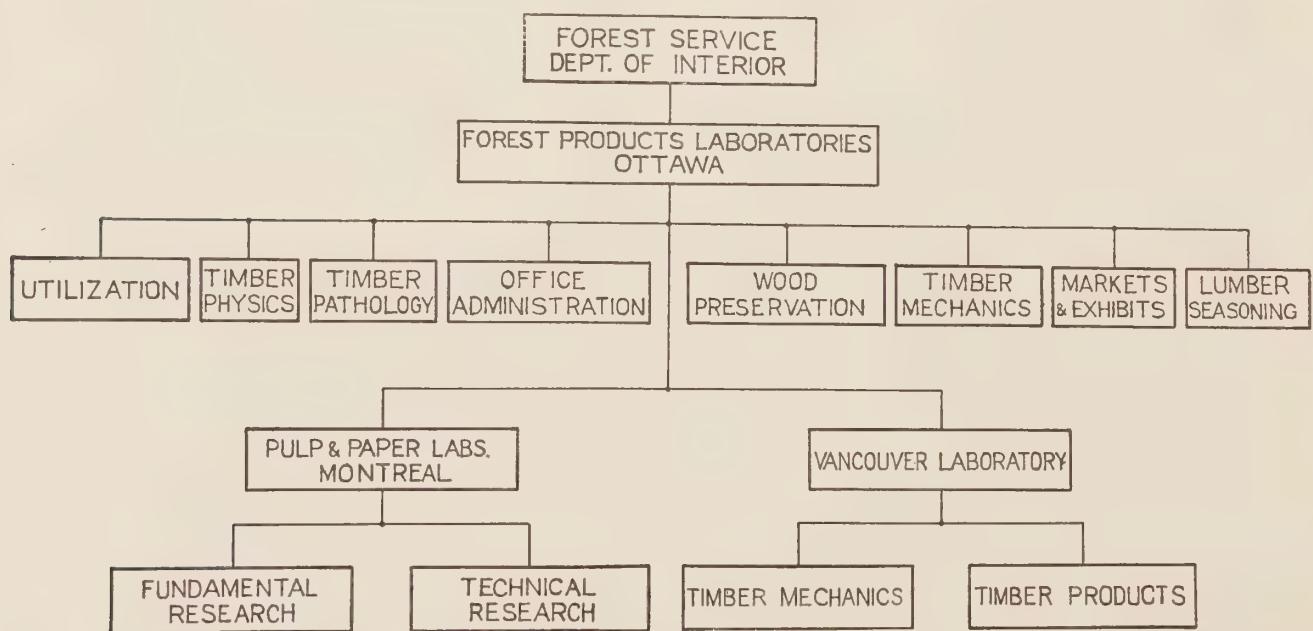
PART OF WOOD-PRESERVATION LABORATORY, OTTAWA.  
The large treating unit to the right is capable of handling a charge of 35 ties.

# *The Forest Products Laboratories of Canada*

and scientific questions which must be answered. In the solution of some of these, the Laboratories have led the way. In many other instances they have worked in close co-operation with industry, to their mutual advantage.

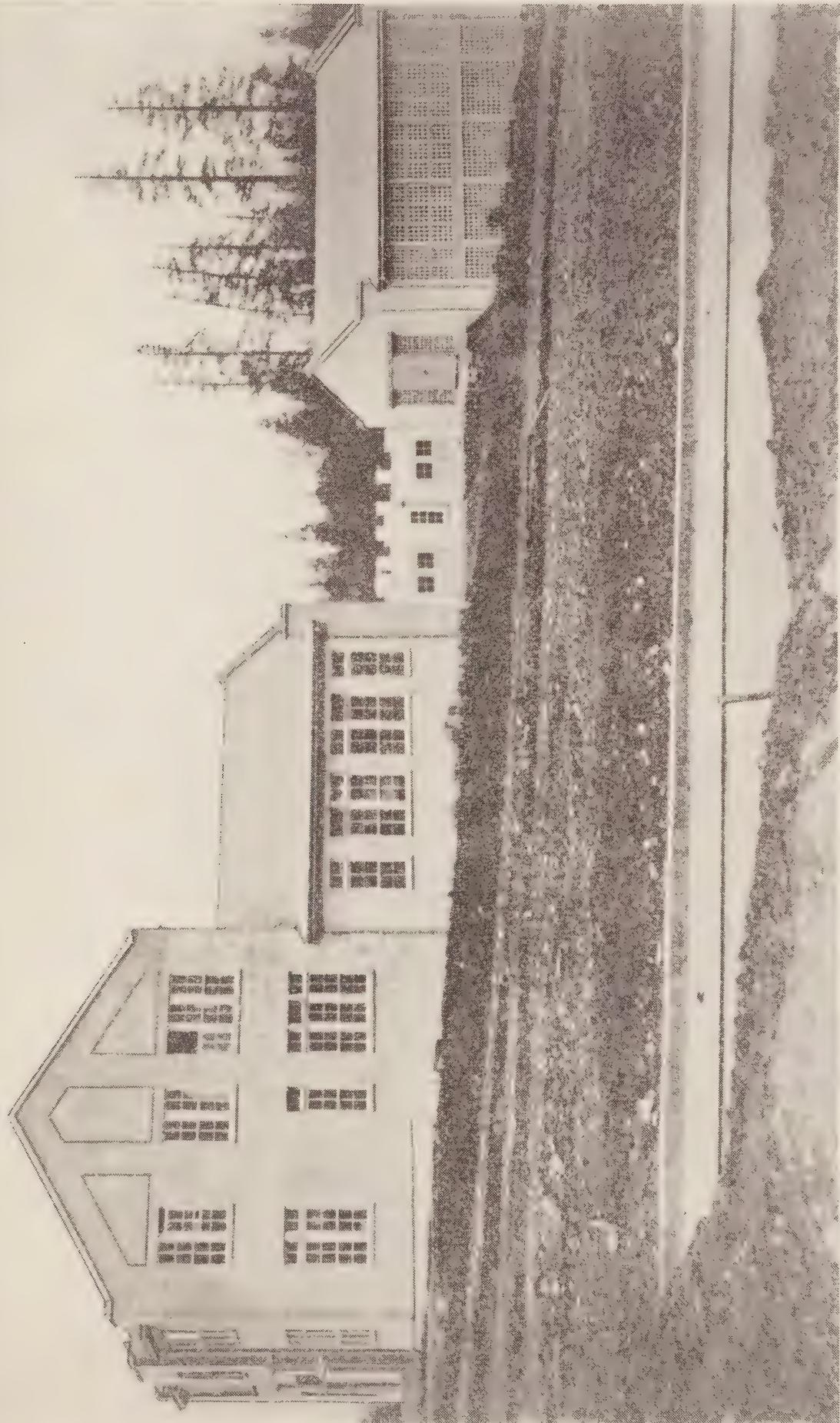
## **ORGANIZATION OF THE FOREST PRODUCTS LABORATORIES**

The scientific nature of the problems presented has resulted in the organization of the work of the Laboratories into a number of divisions, with specialists in different branches of science in charge of the respective divisions. The attached chart illustrates in outline how the whole organization functions. The total staff of the Laboratories consists now of between 90 and 100 employees, over thirty of whom are graduates in different branches of science. The investigative work is carried out in the following divisions:—(a) Pulp and Paper, (b) Wood Preservation, (c) Timber Mechanics, (d) Lumber Seasoning, (e) Timber Physics, (f) Wood Utilization, (g) Timber Pathology, (h) Markets and Exhibits. The research work of the Pulp and Paper Division, Montreal, and of the Vancouver Laboratory operates in two divisions, in each case, as outlined on the chart. It is only possible, here, to indicate, in a general way the nature of the work of the different divisions as now organized.



# *The Forest Products Laboratories of Canada*

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THE VANCOUVER LABORATORY.

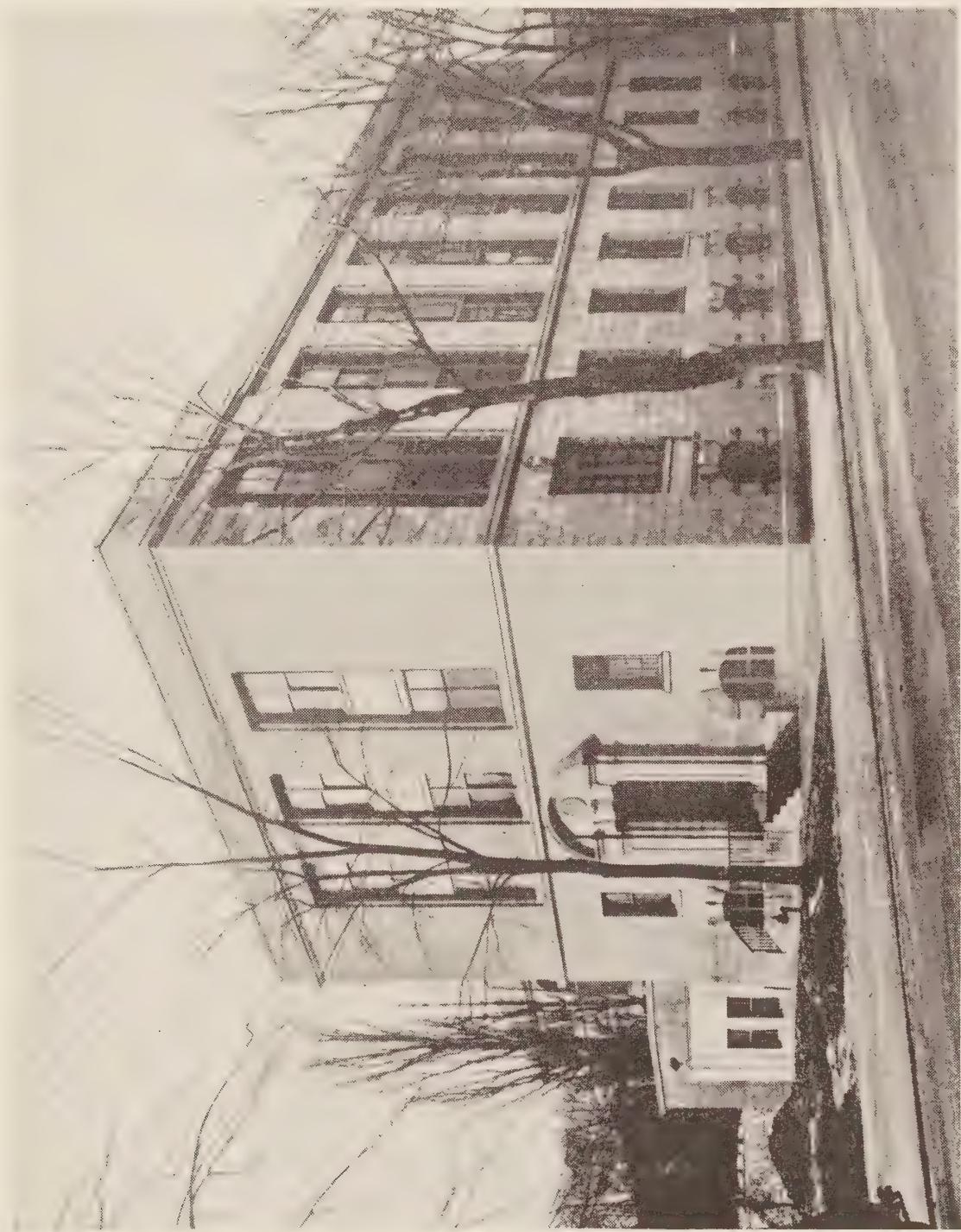
## *Pulp and Paper*

While the pulp and paper industry in Canada has developed at an almost phenomenal rate, methods of operation, standards in quality of pulp and paper, and methods of testing pulp and paper vary widely between plants. Wood is a very complex substance, consisting of cellulose and lignin. With the wood tissue are associated various gums, resins, and oils, varying in amount, quantity, and quality with different species. Scientific problems in the pulp and paper industry are therefore very diverse, very complicated, and very important.

The new Pulp and Paper Laboratories in Montreal are, from the standpoint of experimental equipment, among the finest of their kind in existence. Considerable valuable work has already been done on standard equipment for freeness testing, the pulping qualities of fire-killed wood, the pulping of wheat straw, the use of clear water as a preservative for storing pulp, the manufacture of blotting paper from sulphite pulp, the use of Canadian talc in paper-making, the use of magnesite in the sulphite process, and in many other investigations.

The present program of the Laboratories has been developed in close association with the Technical section of the Pulp and Paper Association. The following are among the subjects for investigation in that program:—

1. Methods of analysis of pulp and paper
2. Sulphite pulp studies
3. Definition of pulp quality
4. Kraft and soda pulps for artificial silk
5. Penetration of fluids in wood
6. Roe-Genberg chlorination number
7. The bleaching of chemical pulps
8. The rod mill for beating kraft and its influence on quality
9. Groundwood studies
10. The printing qualities of paper



THE PULP AND PAPER RESEARCH INSTITUTE, MONTREAL.  
In which the Pulp and Paper division of the Forest Products Laboratories is located.

## *Wood Preservation*

Wood, if completely submerged in fresh water or if kept in a continually dry condition, will last practically indefinitely. On the other hand, if exposed to conditions favourable to the action of wood-destroying fungi it may decay very rapidly. In salt water it may fall a prey to marine borers or on land to wood-boring insects. Some species—as, for example, the cedars—are naturally resistant to decay. Certain species, on the contrary, which are otherwise very valuable for structural purposes may not be very resistant to decay.

In order to protect wood from deterioration in exposed situations, such as in telephone and telegraph poles, railway ties, bridge timbers, piling, cross-arms, and also for general construction in countries infested by white ants, it is frequently treated with creosote, zinc fluoride, sodium fluoride, or some other chemical toxic to wood-destroying fungi and insects.

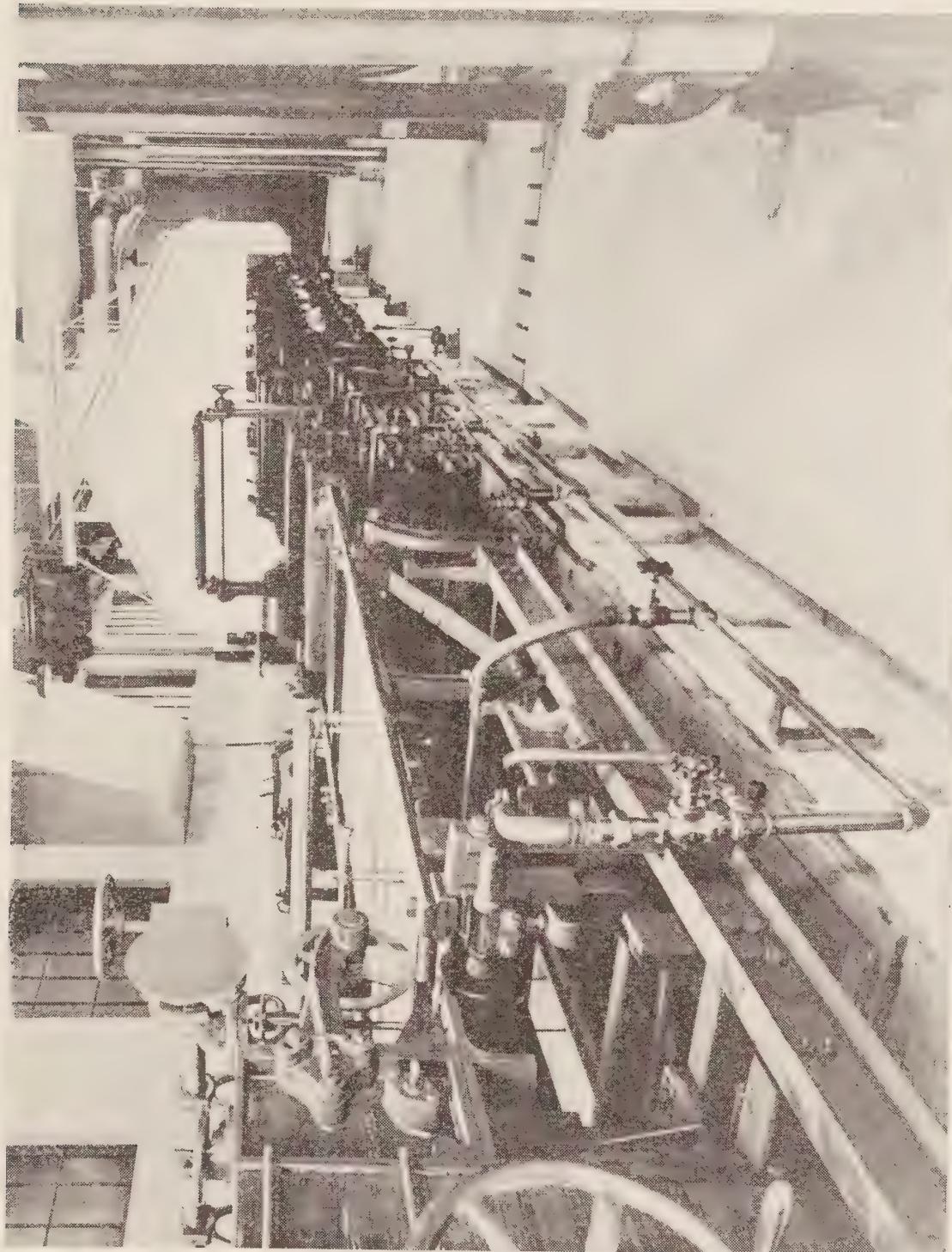
Through the development at the Laboratories of the incising machine and the later acceptance by commercial treating plants of the principle of this machine, it has become possible to treat hardwoods and some of the stronger and more refractory softwoods most desirable for railway ties. This machine has also been responsible for great economies in treatment and much more uniform penetration of the treating liquid.

The following problems are now engaging the attention of the division:—

- (1) Protection of timber from marine borers
- (2) Resistance to change in moisture content of yellow birch ties treated with 70/30 creosote-coaltar mixture (a) with initial air pressure (b) without initial air pressure
- (3) Reduction of leaching of zinc chloride and copper sulphate by second treatment of potassium-ferrocyanide
- (4) Zinc-meta-arsenite experimental tie treatments for service tests

# *The Forest Products Laboratories of Canada*

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GENERAL VIEW OF EXPERIMENTAL PAPER MACHINE FROM WET END.

- (5) Hardwood ties, air-seasoned and creosoted
- (6) Distribution, penetration, and permanence in woods of dinitrophenol
- (7) Investigation of the properties of zinc-meta-arsenite as a wood preservative
- (8) Absorption and penetration of zinc-meta-arsenite and 70130 creosote-coaltar mixture in jack pine ties
- (9) Fire-retardant treatments
- (10) Open-tank treatment
- (11) Steam-seasoning of red pine and jack pine poles
- (12) Heat transfer in timber during preservative treatment
- (13) Sodium chloride as a wood preservative.

### *Timber Mechanics*

Basic data on the mechanical and physical properties of the different species of wood are fundamental to a study of wood uses. Without such data it is impossible to make an intelligent comparison of different species of native woods or of these woods with relation to foreign competing woods. Such studies have shown that Douglas fir has no superior among the softwoods of the world as an all-round wood for heavy structural purposes; they have shown remarkably low factors of shrinkage and expansion in white pine, which, combined with high durability, make it a very valuable wood for a wide variety of uses; they have shown that Sitka spruce, on account of its great strength with relation to its weight, combined with straightness of grain, is a particularly valuable timber for aeroplane construction.

Besides, there are many uses for such information in specifications for structural timbers, in building codes, and in many other ways. One of the most important uses to which such information has been applied is in connection with foreign markets, where choice of material is based on such information in lieu of experience with new woods being offered on the market. In several specific instances, Canadian woods have been favourably established and valuable business secured through such data. The work in timber mechanics has been especially valuable to com-

mittees of the Canadian Engineering Standards Association in drawing up specifications for poles, piling, and other structural timbers.

The Division of Timber Mechanics is also equipped for research in wood glues and for conducting tests on boxes, crates, barrels, and other containers. Railways, shipping companies, and other organizations suffering freight claims on account of damaged containers have availed themselves of the laboratories' facilities for testing containers and for suggesting improvements in container design.

The following problems in timber mechanics are receiving attention:—

- (1) The mechanical and physical properties of woods grown in Canada
- (2) Strength of glued joints
- (3) Retention of nails and screws by wood
- (4) Mechanical tests on white spruce
- (5) Design of nailed wooden boxes
- (6) Strength of telephone poles
- (7) Strength of structural timbers
- (8) Strength of Canadian woods for mining timbers
- (9) The cutting efficiency of saws
- (10) The relationship of moisture content to the strength of wood
- (11) Tests of treated and untreated Douglas fir poles
- (12) The strength of Douglas fir beams after long use

### *Lumber Seasoning*

Except for use in very rough or temporary work, lumber is seasoned, to some degree, before it is put into use. The more refined the use for which it is intended, the greater must be the care in seasoning. Unsatisfactory seasoning of timber is the most frequent source of complaint and claims between lumber dealers and users. Heavy losses are sustained in both air-seasoning and kiln-drying, some authorities estimating average losses at as high as 7 per cent of the total value of all rough lumber cut.

While sufficient information is not yet available to show the full extent of lumber seasoning losses in Canada, as already mentioned, instances have come to the attention of the laboratories of kiln-drying losses as high as 20 per cent of the value of the lumber, whereas in other instances, where the importance of careful dry-kiln operation has been more fully appreciated, lumber has been kiln-dried with a loss so low as to be inappreciable.

In order to curtail seasoning losses, the Laboratories are carrying on special investigations. They are supplied with experimental kilns, where satisfactory drying schedules may be developed and where lumber-seasoning specialists may demonstrate to dry-kiln operators the principles underlying good kiln design and operation, and the equipment necessary to put these principles into effect.

Among the more important problems in lumber seasoning engaging the Laboratories' attention are the following:—

- (1) Kiln-drying schedules
- (2) Equilibrium moisture content of representative Canadian woods
- (3) Air-seasoning studies
- (4) Shrinkage and expansion studies of commercial sizes of representative Canadian woods
- (5) Absorption of moisture by seasoned lumber
- (6) Kiln-drying of shingles

### *Timber Pathology*

Staining and decaying of wood, in the forest, in the log, in the lumber yard, and in service are together responsible for very heavy annual losses. Some stains cause no appreciable reduction in the strength of wood but do result in reduction in grade and consequently in value, of frequently over \$10 per thousand feet board measure. This is particularly the case in blue stain of the sapwood of some of the pines, though it is not confined to pine. Red rot in jack pine and lodgepole pine railway ties has been a source of contention amongst interested parties. Slime in pulp mills and the action of fungi in stored pulp are

sources of very considerable trouble and loss. The storing of timber in the holds of vessels has frequently caused serious losses. Decay in mill-buildings, particularly those in which the atmospheric humidity and temperature are high, has in many cases been very rapid.

The study of these and related problems is carried out in the Division of Timber Pathology, the work of which dovetails very closely into that of other divisions, such as Timber Mechanics, Wood Preservation, Pulp and Paper, and Lumber Seasoning.

The following problems in timber pathology are receiving attention:—

- (1) Reference collection of pathological material
- (2) Red stain in jack pine; its development in creosoted and untreated railway ties under service conditions
- (3) A comparative study of the effect of *Trametes Pini* and a second red-staining fungus on the strength of jack pine
- (4) Blue stain in white pine
- (5) The systematic study of fungi causing staining in the sapwood of softwoods
- (6) Red heart in birch
- (7) The effect of purple stains on the properties of Western red cedar and Douglas fir
- (8) Development of stain and decay in lumber during shipment by water
- (9) Relative durability of untreated British Columbia woods
- (10) The parasitism or saprophytism of certain wood-destroying fungi
- (11) The effect of kiln-drying upon the sterilization of lumber.

### *Timber Physics*

The different species of wood are very similar in chemical composition. The physical properties of different species, however, differ widely. Variation in physical properties is accompanied by a closely corresponding variation in mechanical properties and also in uses to which the various species may be put.

The study of the physical properties of wood is, therefore, fundamental to the study of wood uses. The characteristics of the fibres of different species of wood has an exceedingly important bearing on their use for pulp and paper. The physical structure of the different woods has also a very direct relation to the movement of liquids and therefore to the ease with which they season, and to the penetration of the cooking liquor in chemical pulp manufacture and of the preservatives used to prevent decay.

Wood structure has also an important bearing on the sound- and heat-insulating properties of different woods and on their resonant qualities for musical instruments.

The study of the physical properties of woods and problems of practical importance relating to these properties constitutes the work of the Division of Timber Physics. Some of the problems at present receiving attention are.

- (1) A study of the variability of important Canadian woods
- (2) The determination of fibre dimensions in Engelmann spruce (*Picea Engelmanni*, Engelm.)
- (3) The cause of bird's-eye figure in sugar maple (*Acer saccharum*, Marsh.)
- (4) The relative permeability of woods by fluids
- (5) A study of the factors affecting the sinkage of logs in water.

### *Wood Utilization*

The work of the Laboratories relates broadly to two types of work. The first is concerned with those fundamental scientific problems which must be worked out before progress can be made in industrial development. The second is concerned more closely with the application of existing scientific knowledge to industrial problems, in order to effect improvement in operating efficiency and in the conservation of material.

In order that the program and viewpoint of the Laboratories may be kept in proper balance and that its work may be most effective, it has been considered advisable to establish a division whose main functions are to keep

in touch with industrial problems in wood utilization, to watch the trend of development in wood uses, to make surveys of problems of major importance in order to find new uses for wood—particularly those species now difficult to market—and in other ways to form a link between wood-using industries and those divisions of the Laboratories whose work is more strictly scientific in nature.

The following are some of the problems which have already received some attention or for which plans are being made:—

- (1) The effect of seasoning on the floatability of logs
- (2) The investigation of the sources of sawmill waste in softwood and hardwood mills
- (3) An investigation of the manufacture of plywood in Canada
- (4) Logging waste
- (5) Properties and uses of commercial woods of Canada
- (6) Present and possible uses for poplar and white birch.

### *Markets and Exhibits*

The Laboratories are freely consulted regarding markets for Canadian timber both for domestic and foreign use. Canadian Trade Commissioners in foreign countries are faced with many problems regarding relative merits of Canadian timbers and of competing timbers for specific purposes. Through such channels the Laboratories have been able, on numerous occasions, to provide data of very practical value, and in many cases such information has been directly responsible for opening up new markets for Canadian timbers. This has been particularly the case with respect to Douglas fir, yellow birch, western hemlock, Sitka spruce, and certain of the pines.

The Laboratories have many requests from foreign sources for samples of Canadian woods, carefully identified, for exhibit purposes and for scientific study in foreign universities and colleges interested in forestry or botany. Such requests receive careful attention, as they are valuable in disseminating knowledge of the properties of Canadian

timbers. The Laboratories have also encouraged in Canada a better knowledge of Canadian woods, and with that end in view have supplied on request hundreds of sets of specimens of Canadian woods, properly labelled to show both common and botanical names, to manual-training schools, boys' clubs, and other organizations interested in using home-grown woods. The Laboratories are constantly being called on to participate in the display of exhibits of woods at large exhibitions in Canada and in foreign countries where Canada is participating in important exhibitions, such as at Wembley, at Antwerp, and at Buenos Aires.

### *Technical Service to Wood-using Industries*

The services of the Forest Products Laboratories are not confined solely to the carrying out of definite projects which appear in the program planned for any particular year. To a very rapidly increasing degree, they are being used as a bureau of technical information by the wood-using industries. Inquiries of both Canadian and foreign origin are received on nearly every conceivable phase of wood utilization. In so far as is practicable, the Laboratories endeavour to give the benefits of data obtained from its own researches or from other sources of reference available in the very complete reference library on wood utilization which is an important part of the Laboratories' facilities. In the past year over one thousand inquiries for technical information were dealt with.

While in some fields of investigation reliable information is very meagre, in a great many other fields the Laboratories are very far in advance of industry. A great deal of information is available which is not being put to use to the extent to which it might be used. For this reason the answering of technical inquiries and the dissemination of information obtained by the Laboratories are important media for making effective, in a practical way, the scientific work of the Laboratories.

**Department of the Interior—Forest Service  
Forest Products Laboratories of Canada**

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**LIST OF PUBLICATIONS**



## LIST OF PUBLICATIONS

Bulletin 49 Treated wood-block paving, by W. G. Mitchell  
" 59 Canadian woods for structural timbers, by H. N. Lee  
" 66 Utilization of waste sulphite liquor, by B. Johnsen and R. W. Hovey  
" 71 Canadian Sitka spruce, its mechanical and physical properties, by L. L. Brown  
" 74 Distillation of hardwoods in Canada, by J. S. Bates  
" 76 Pulping qualities of fire-killed wood, by E. P. Cameron and Wm. Lodge  
" 78 Some commercial softwoods of British Columbia, by T. A. McElhanney and R. S. Perry

Circular 16 Preservative treatment of fence-posts, by J. A. Coderre  
" \*18 The kiln-drying of British Columbia softwoods  
" 19 Canadian softwoods, by W. B. Stokes  
" 21 Tests of green-cut Western cedar poles, by R. S. Perry and T. A. McElhanney  
" 22 Report on tests of the relative strength of green-cut and fire-killed Western red cedar pole timber, by T. A. McElhanney and R. S. Perry  
" 23 Absorption of moisture by kiln-dried lumber, by J. H. Jenkins  
" \*24 Strength of reinforced and unreinforced butter and cheese boxes, by G. H. Rochester  
" 25 List of Forest Service publications  
" 26 Creosote treatment of Douglas fir, by J. F. Harkom  
" 27 Stain and decay in lumber-seasoning yards, by Clara W. Fritz  
" 28 Strength tests of creosoted Douglas fir beams, by J. F. Harkom and G. H. Rochester

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\*These publications may be obtained in French

*Papers presented to the 3rd British Empire Forestry Conference, 1928*

Timber testing in Canada, by T. A. McElhanney

Timber pathology in relation to wood utilization in Canada,  
by Clara W. Fritz

Wood preservation in Canada, by J. F. Harkom

Pulp and paper research in Canada, by E. P. Cameron

Timber physics research in Canada, by J. D. Hale

*Miscellaneous publications available for distribution as reprints or in some similar form*

Losses in sulphite pulp manufacture, by O. F. Bryant.  
(Read before Technical section of Canadian Pulp and Paper Association, Feb. 12, 1915. Published in Pulp & Paper Magazine, Mar. 1, 1915.)

Fibre structure of Canadian woods, by H. N. Lee. (Canada Lumberman, July, 1916)

Staining of wood fibres for permanent microscopic mounts, by H. N. Lee. (Botanical Gazette, Oct., 1916)

Present and possible products from Canadian woods, by J. S. Bates. (Read before Canadian Society of Civil Engineers, Montreal. April 19, 1917. Published in Transactions of Society Vol. 31, Part 1, 1917. Pulp and Paper Magazine, June 7, 1917.)

Decayed wood and the fungi therein as seen with the microscope, by H. N. Lee. (Read before National Association of Cotton Manufacturers. Published in Transactions of the Association, No. 102, 1917)

Injurious rosin in sulphite pulp, by B. Johnsen. (Pulp and Paper Magazine, June 14, 1917).

Efficiency of the newsprint splice, by L. N. Seaman. (Pulp and Paper Magazine, Oct. 2, 1919).

Routine methods for the examination of wood-pulp adopted at Forest Products Laboratories of Canada, by E. P. Cameron. (Pulp and Paper Magazine, Dec. 21, 1922.)

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Color test for chloroform and chloral hydrate, by J. H. Ross. (Journal of Biological Chemistry, Dec., 1923.)

Structure of wood, by W. B. Stokes. (Reprint from Timber News, 1924)

Economy by wood preservation, by J. F. Harkom. (Natural Resources of Canada, Aug., 1925)

Blue stain; a cause of serious loss to manufacturers of white pine lumber, by Clara W. Fritz. (Canada Lumberman, Aug. 15, 1929)

Effects of seasoning on floatability of logs, by K. G. Fensom. (Paper read at annual meeting of Woodlands section of Canadian Pulp and Paper Association, Jan., 1930).

Preservative treatment of mine timbers, by J. F. Harkom. (Paper presented at annual meeting of the Canadian Institute of Mining and Metallurgy, March 5-7, 1930)

Manufacture of charcoal without recovery of by-products, by J. F. Harkom. (Mimeographed article)

Series of articles on Canadian woods, by K. G. Fensom. (Published in Canadian Woodworker, consecutively from May, 1930 to May, 1931: 13 articles.)

*Note:*—Numerous publications of the Forest Products Laboratories appear in various periodicals. A list of these may be had on application.













